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(54) Title: POTENTIAL ENERGY FIELD REACTOR, PROCESS FOR PREPARING AND PROCESS FOR UTILIZING SAME

(57) Abstract

There is provided a process for the preparation of a potential energy field reactor for processing a reagent in non–aqueous and aqueous feedstocks with reactant particles adsorbed therein, such as that which comprises providing a flow pathway in said reactor having at least one surface, suitably in the form of a spiral support, feeding to said pathway, reactant particles and at least one initial reagent reactable therewith during their passage through said pathway in such a manner that an energy potential difference is generated between the beginning of said pathway and its end and said reactant particles become polarized whereby polarized particles adhere to each other and become immobilized within said pathway. There is also disclosed a reactor made in this manner, and a method for utilizing it.

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POTENTIAL ENERGY FIELD REACTOR, PROCESS FOR PREPARING AND PROCESS FOR UTILIZING SAME

BACKGROUND OF THE INVENTION

Field of the invention

Continuous flow reactors

Discussion of the Prior Art

In flow reactors, the distance between the flowing medium and the reactant bearing surface (or catalyst or biocatalyst) is purposely kept very small in order to assure efficient contact between reactants and catalyst. In the patent to Goldberg and Chen (US 4689302) a flow channel spacing is recommended in the range of from (0.0127 to 0.0762 cm or 0.005" to 0.030", referred to herein-below as the Amerace cartridge).

When used with bacteria for oxidation of phenol as a model pollutant (Timothy L. Borkowski *Quantitative Studies of an Immobilized Cell Oxidative Bioreactor*, MS Env Sci New Jersey Institute of Technology (1995); Chad Sheng *Analysis of the Oxidation of Isotox® by Immobilized Bacteria*, MS Env Sci New Jersey Institute of Technology (1995)James Joseph Woods *Aeration and Operation of an Immobilized Cell Oxidative Bioreactor*, MS Env Sci New Jersey Institute of Technology (1995)), the Amerace cartridge displayed substantial oxidation rates. However, it was believed that in accordance with the principles discussed below, a more efficient cartridge could be developed which would differ from the Amerace cartridge in significant ways.

Conventional design techniques tend toward a very narrow spacing to reduce diffusion of reactants toward, and products away from the reaction site. This has the disadvantage of high pressure drops across the reactor, requiring costly pumps and utilities. The PEF reactor uses the field

strength to advantage, which for the spiral sheet reactor with oxidizing bacteria means much higher spacings than the range preferred and specifically claimed by Goldberg and Chen.

Both sheet thickness and porosity may affect the nature of the field buildup. Sheet thickness increases spacing, decreasing field intensity, and porosity tends to allow the radial movement of charged particles, allowing electric current flow.

The prior art shows that conventional thinking teaches away from the approach of the present invention. In a commonly accepted immunology text, Kuby (Immunology, 2nd ed, New York: W. H. Freeman and Company (1994)) teaches that cells in culture grow into monolayers. This is contrary to the thrust of the present invention, which holds that film density and hence film thickness (which can be much more than one layer thick), are determined by energy factors.

Perry and Chilton's internationally recognized handbook *Chemical Engineers' Handbook* 5th edition New York: McGraw-Hill Book Company (1973) teaches away from the present invention by stating that catalyst porosity is important, as is surface area per unit volume, the latter of which is higher for smaller particles. The position taken by the present invention is that reactant particle size and porosity are not the critical factors, the over-all energetic field drives the reaction.

Polk and Rostow (*Handbook of Biological Effects of Electromagnetic Fields* New York: CRC Press (1996)) state that electromagnetic fields affect biological systems. However, they do not teach how to quantify these effects and use these quantifications to design, optimize, or control reactors.

Bensom, Grissom, and coworkers (*Magnetic field enhancement of antibiotic activity in biofilm forming Pseudomonas aeruginosa* ASAIO (Am Soc for Artif Int Organs) Journal (1994) M371) show that magnetic fields enhance gentamicin activity against bacteria, commenting that the cellular and mucoid components in a biofilm interact in a complex manner. They fail to teach how to quantify this behavior for use in biofilm or other reactors.

SUMMARY OF THE INVENTION

There is disclosed a process for the preparation of a fluid flow reactor of a novel type designated as a potential energy field reactor. Such a reactor is useful for processing a reagent in aqueous or non-aqueous feedstocks with, reactant particles adsorbed therein. The reagent is not limited in category, provided it can make reactive contact with the reactant particles. The reagent may be a substance which it is desired to convert into another useful substance or it may be a pollutant in the feed stock which it is desired to destroy or make harmless. The present invention shows that reactions may be controlled by self- or externally generated magnetic fields.

This novel process comprises providing a flow pathway in a reactor which has at least one surface, then feeding into this pathway, reactant particles and at least one initial reagent reactable with these particles during their passage through said pathway. In continuous flow reactors heretofore, other than fluid bed reactors, it has been customary to provide either a porous surface into which the particles can be "locked", or to bond the particles to the surface of the reactor with linking agents.

It has been the surprising finding herein that by proper adjustment of the actual spacing in the reactor and utilization of an appropriate flow rate the reactant particles can be immobilized within the flow pathway without the means of the prior art. The key to this methodology is the surprising finding that when a reaction takes place in a flow reactor, an energy

potential difference is generated between the beginning of said pathway and its end. This polarization may be electrical, magnetic or both. As a result of this energy field, the reactant particles become polarized, and these polarized particles align with each other and become immobilized within the pathway.

In the general method of setting up the reactor, reactant particles and said reagent are fed to the reactor until reactant particles adhere to each other to a sufficient extent to effectively adhere to the surface of the flow path. Suitably the feeding continues until the surface of the pathway is coated with a plurality of layers of the reactant particles.

While the invention is not limited thereto, a major type of reactant is a biocatalyst, this may be aerobic or anaerobic suitably enzymes, bacteria, organelles, yeasts, leucocytes, hemocytes and fungi or the like or their products.

The feedstock may be aqueous or non-aqueous. While in many cases the initial reagent to set up the system is different from the reagent to be processed, the system is not so limited the initial reagent may well be the reagent in the feedstock to be processed.

Where the reactant is bacteria it may comprise aerobic or anaerobic bacteria. Where the reactant is aerobic bacteria, the initial reagent is an oxidizing agent, such as oxygen or even a pollutant to be degraded. A highly suitable reactant in this area is activated sludge, suitably screened to have a particle size of less than 300 microns.

The invention also comprises potential energy field reactors made by any of the foregoing procedures as well as methods of processing one or more components of a feedstock which comprises feeding said feedstock

to such a reactor. An example of a such a procedure comprises removing phenolic components from aqueous feedstock which comprises feeding said feedstock to a reactor containing activated sludge, suitably by recycling said feedstock through said reactor till no measurable amount of phenolic components is detectable. Other uses will be discussed below.

The use of the potential energy field (PEF) principles demonstrated herein, leads to the design of a new cartridge with dramatically higher performance. The new method increases the average reactant, suitably, the bacterial packing density by several fold by taking into consideration PEF dynamics of the reaction, suitably an oxidation reaction, itself.

The PEF reactor is designed on the basis of totally different principles from reactors of the prior art used for the same purpose. The reactants or catalysts need not be chemically fixed. The potential energy field, built for example by oxidizing bacteria determines the packing of the cells, which in this case attach by themselves and form a thicker film than is normally obtained by chemical means. Spacing, sheet thickness, and porosity are not restricted. Sheet porosity is not required.

There are three determinative variables for this method. The first variable is the driving force of the reaction, which may be represented by a concentration and/or concentration difference, or other measurable parameter such as such as temperature, pH, pressure, color, etc.

The second determinative variable represents the energy field intensity, I, which is determined by calculation.

The third determinative variable is a reactor parameter, such as the hydraulic density, a representation of the catalyst density. Reaction rates and/or other critical reactor parameters may be selected as well.

Combinations of the above parameters may also be used to obtain any or all of the three determinative variables.

Brief Description of the Drawings

Figure 1 is a schematic illustration of the principles of the present invention. Contaminated water containing dissolved oxygen enters three typical reaction chambers show below. All three represent bacterial bio-reactors. Dissolved oxygen entering at A is consumed as bacteria catalyze the oxidation of phenol. The concentration of oxygen leading at B is therefore less, creating an oxygen chemical potential difference, building the potential field.

Figure 2 is a schematic representation of the spiral cartridge embodiment of the present invention. Top view shows flow entering the core, moving through the slit at A, and exiting at B. Due to potential energy field buildup and bacterial motility, an uneven thickness tends to form within the walls of the chamber. In this case, the bacteria are shown to concentrate densely near the end (inset, left) of the flow path. Near the entrance, the density is shown to be light (inset, below). A high pressure drop for a given amount of bacteria, especially prevalent at the most densely packed section at left, leads to failure. Spacing width is W, and $L = L1 + L2$, is the average thickness of immobilized bacteria.

Figure 3 is a schematic representation of a reaction system utilizing a spiral cartridge of the present invention.

Description of the Preferred Embodiments

The primary tenet on which this invention rests is that every reaction has a dynamic energy pattern made up of electrical, magnetic, and chemical potential energies in addition to the more conventional internal energy terms. By monitoring a measurable parameter such as concentration or concentration difference, one obtains an indication of the relative strength of this field. This is used to calculate a field intensity profile. Reactant, suitably

catalyst, packing density is calculated for low and high packings, as are film thickness and bed expansion volume. A decision is made to increase or decrease the field intensity on the basis of reactant, suitably bacterial bed expansion within the catalyst film. A configurational parameter such as spacing is changed and the field intensity profile re-calculated. A new reactor is designed and the process is repeated as necessary.

This method of design of overcomes limitations which cause low and uneven catalyst distribution, limit over-all productivity, and are costly. In, for example, bacterial oxidation of phenol, three of many possible reactor configurations are shown.

Potential fields are generated whether the catalyst, in this case bacteria, is free to move within the fluid, or immobilized as a film onto a biosupport sheet or within a gel such as alginate. The fluid, which may be any gas or liquid, such as water carrying the contaminant phenol. This fluid is not necessarily always in motion, but may also be supplied in a batch or a series of batches, and with the fluid velocity at times being zero. The support sheet may be kept as a single sheet or several parallel and straight sheets, or a sheet or sheets could be rolled into a spiral, or biosupport surfaces could be shaped into any desired configuration. Gel bead and other reactors are also eligible for this treatment.

Phenol is oxidized as the fluid, carrying dissolved atmospheric or added oxygen, flows past the bacteria. Oxygen is consumed and carbon dioxide and intermediates are formed. This generates differences in concentration of dissolved oxygen and carbon dioxide across the regions represented by lines A and B in Figure 1.

This invention may, in addition to oxidation, be applied as well to other reaction systems such as, but not limited to, anaerobic digestion to

make methane and carbon dioxide, yeast fermentation to produce alcohol and carbon dioxide and potential high protein foods, immune system control reactions, blood cell or tissue cell reactions, enzyme reactions, organelle reactions, ordinary chemical systems, etc.

This invention is not limited to self-immobilizing catalysts such as bacteria, free catalysts, but also to chemically and physically affixed catalysts. It is also applicable to reactions not requiring or no longer requiring catalytic reactants.

Detailed Description of the Drawings

Figure 2A shows a spiral cartridge core 10 comprising a spiral sheet 12 having an outer surface 14 and an inner surface 16. Flow enters at the center of the core at 20 and exits at the periphery at the core 30. The bacteria 40 are similarly injected at 20 and exit at 30. As shown in Figure 2B, they start to accumulate on surfaces 14 and 16. Ultimately, they build up to coatings as shown in Figure 2C where the coating on surface 14 has a width L_1 and the coating on surface 16 has a coating width L_2, giving a spacing width W.

The entire system is illustrated in Figure 3. Here, the last two digits have the same meaning as those set forth above with respect to Figure 2 but are prefixed by the number 1. Thus, the cartridge case 100 comprises the core 110. Bacteria, and later the liquid to be purified, is injected at the center of the core 120 and exits at 130 into sample 160 from whence surplus liquid 162 overflows through 164 to reservoir 150.

In order to sample inflow composition and pressure etc., a sample is taken at 124 in the core of the cartridge and proceeds via conduit 182 to peristaltic pump 184 and from thence via conduit 185 to DO probe 190, whose readings are recorded by chart recorder 192. The flow continues

from probe 190 through conduit 180 to reservoir 150 containing liquid 152.

The liquid in the reservoir exits through exit 154 via conduit 156 by means of recirculation pump 158 and is then recycled via conduit 170 to the cartridge at 120. The pressure in 170 is measured by pressure gauge 180.

Air is injected into the system at point 172 in conduit 170 and into the reservoir at point 174.

Example Application of the Design Method

Description	Equation	Formula	Example 1 Gel Beads	Example 2 Amerace Cartridge	Example 3 SRE C125 Cartridge	Example 3 SRE C250 Cartridge
Measure reactor length, the distance from Point A at the entrance to point B at the exit of the reactor, as shown in Figure 1	1	L = B - A	6 cm	610 cm	274 cm	221 cm
Calculate field intensity	2	I_1 = 1.0 Units/L	0.167 U/cm	0.00164 U/cm	0.00365 U/cm	0.00452 U/cm
Calculate amplification	3	X (see note 1)	1.0	146	36.1	16.0
Calculate amplified intensity	4	$I_2 = I_1 \times X$	0.167 U/cm	0.239 U/cm	0.132 U/cm	0.0723 U/cm

Gel bead reactor displays major bed expansion at this I_2: 0.167 U/cm. Maximum acceptable I_2 = 0.24 U/cm. Therefore, the Amerace cartridge I_2 is unacceptably high. Both SRE cartridges are acceptable.

NOTE 1: The gel reactor, is 11.5 cm diameter as described by Lakhwala, and is cylindrical. It does not wrap or coil to increase amplification.

Spiral amplification calculations are given below in Table A.

Method of Calculating Amplification of Field Intensity

A baseline (at normal respiration) oxygen concentration drop measured as 20 nanomoles per ml (Sheng) is observed across the cartridge or the gel bead (Fig. 1). Let this equate to one Unit of field intensity, I. For convention, assume the direction of intensity that of lowering oxygen concentration. Therefore, the field intensity increases radially outward. Each time a complete wrap is made in the spiral cartridge, a new rung is generated. The intensity of each rung is approximated by 1 Units per cm times the average circumference, divided by the spacing, plus a similarly calculated amount for the field it shares with each of the other rungs. This is summarized in Table A for the spiral cartridges.

Table A - Amplification Calculation

Diam. - Spacing Biosupport Area	No. of Rungs	Average I per Rung	Amplification I x Rungs
Amerace 5 in dia, about 1/16 sp 50 sq. ft.	25	5.84	146
SRE 5 in dia, 1/8 sp 22.5 sq. ft.	11	3.28	26.1
SRE 5 in dia, 1/4 sp 18.8 sq. ft.	8	2.00	16.0
SRE 10 in dia, 1/4 sp 50 sq. ft.	15	1.78	26.7
SRE 30 in dia, 1/4 sp 500 sq. ft.	50	1.59	79.5

The above SRE cartridges are acceptable.

This invention claims any spacing higher than the Amerace spacing.

Table B - Comparison of SRE and Amerace Cartridges

	Loading g. bacteria	Bacteria Packing mg/cm^2	Avg. I Units (I difference, high-low)	Oxidation Rate $mg/hr/ft^2$ (No. of Runs)
Amerace: High Loading	75	1.62	5.84	10 (57)
Amerace: Low Loading	25	0.538	(2.78)	
SRE: High Loading	150	7.17	3.28	21 (31)
SRE: Low Loading	32.8	1.57	(1.30)	

The operating rate per unit of biosupport for the SRE cartridge is 2.1 times that of the Amerace.

Sometimes a reaction proceeds while the measured concentration difference appears to be zero. In that case, other indicators may be used, for example, the oxygen concentration reading at that rate. For oxidation, this phenomenon might be caused by the formation of circulating enzymes or auto-oxidizing intermediates, both claimed in this invention.

EXAMPLE

A comparative test was carried out utilizing a standard Amerace/FMC type cartridge in accordance with the patent of Goldberg and Chen, and a cartridge (SRE), not initially loaded with bacteria, having a wider spacing. The general parameters are set forth on Table 1 below. Both cartridges were run in a test system such as illustrated in Figure 3. It should be noted with respect to Table 1, that the designated "initially dry biomass" was actually measured after completion of the experiment.

The SRE (present invention) cartridge was prepared in the following manner.

Aerated water was pumped through the cartridge system shown in Figure 3, utilizing a cartridge with dimensions shown in Table 1. The

oxygen was measured at the reservoir which corresponds to the input location (A) of Figure 1 and also at the sump which is output location (B) of Figure 1.

Bacteria (screened activated sludge under 300 microns) are fed into the reservoir and circulation continued for between 1 and 12 hours under the flow conditions shown in Table 1, until equilibration is reached. A plot is made showing the level of difference in oxygen levels between the input and the output against time.

The polarity of the system runs in the direction of reduced oxygen content.

Varying amounts of contaminant, i.e., phenol, are fed to the system and the results set forth for the SRE cartridge on Table 2, Sheet 1, and for the FMC cartridge on Table 3, Sheets 1 and 2.

TABLE 1

Spiral Polymeric Sheet Cartridge

Company	SRE	AMERACE
Spacing (inch)	1/8 (3.2 mm)	1/16 (1.6 mm)
Height of sheet (ft)	2.42 (29 inches)	2.42 (29 inches)
Length of sheet (ft)	9	20 ft
Size of sheet (ft^2)	21.8	48.4
Initial dry biomass (g)	32.8	11.15
Aeration	Yes	Yes
Recirculating water flow (liters/minute)	11.36 (3 gpm)	< 2
Pressure (psi)	3.5 - 7.0	7.5 - 25 (usually, 10 psi)
Water temperature (°C)	35 - 37	36 - 39
Initial water volume in system (liters)	70 - 90	40 - 44

TABLE 2

Sheet1

SRE cartridge						
Size of sheet:	32.8	ft^2				
# of run	Amount of phenol (g)	Total water volume (L)	Conc. of phenol (mg/L)	Reaction time (hour)	Reaction rate (mg/hour)	Reactor capacity (mg/hr/ft^2)
# Phe-5	7.5	78.7	95	10.3	728	22
# Phe-6	1.95	65	30	3.2	609	19
# Phe-7	5.04	77	65	7	720	22
# Phe-8	14.42	68	212	12.8	1127	34
# Phe-9	5.16	81.8	63	5.2	992	30
# Phe-10	0.56	64	9	1.8	311	9
# Phe-11	1.2	61.5	20	1.7	706	22
# Phe-12	3.07	76.6	40	3.3	930	28
# Phe-13	5.2	65	80	5.2	1000	30
# Phe-14	10.25	73.5	139	10.7	958	29
# Phe-15	19.75	75.6	261	15.5	1274	39
# Phe-16	32.2	92	350	22.7	1419	43
# Phe-17	22.75	81.3	280	17.3	1315	40
# Phe-18	3.02	94.35	32	20.2	150	5
# Phe-19	10	105.8	95	13.25	755	23
# Phe-20	20	81.84	244	49.1	407	12
# Phe-21						
# Phe-22	10	108.9	92	14	714	22
# Phe-23	10	83.9	119	14.25	702	21
# Phe-24	10	84.4	118	19.45	514	16
# Phe-25	7	79.8	88	8.9	787	24
# Phe-26	13	81.8	159	20.6	631	19
# Phe-27	10	92.2	108	24.4	410	12
# Phe-28	10	100	100	17.1	585	18
# Phe-29	20	75.6	265			
# Phe-30	20	86.5	231			
# Phe-31	10	75	133	30.4	329	10
# Phe-32	10	87	115	21.2	472	14
# Phe-33	5	82.9	60	9.75	513	16
# Phe-34	10	75.9	132	29.2	342	10
# Phe-35	1	79.8	13			
# Phe-36	5	87	57	8.9	562	17
# Phe-37	10	94.4	106			
# Phe-38	10	83.4	120	36	278	8
# Phe-39	10	75.6	132	17.75	563	17
# Phe-40	17.1	85.5	200	40.08	427	13
				Total (31 runs) :		647
				Average (mg/hour/ft^2):		21

Sheet2

# - 77	1.5	43.69	34	4.1	366	8
# - 78	1	43.69	23	2.7	370	5
# - 79	2.5	43.69	57	6.7	373	9
# - 81	2.5	43.34	58	6.4	391	8
# - 83	5	43.34	115	8.4	595	12
# - 84	2	43.6	46	4.1	488	10
# - 85	5	43.34	115	12.2	410	3
# - 86	5	43.34	115	17.3	289	6
# - 88	2.5	43.34	58	9.25	270	3
# - 89	1.5	43.34	35	7.5	200	4
# - 90	5	43.34	115	32.9	152	3
# - 91	2.5	43.34	58	8.1	309	6
# - 92	1.5	43.34	35	4.9	306	6
# - 93	2.5	43.34	58	7.9	316	7
# - 94	2.5	43.34	58	7	357	7
# - 95	2	43.69	46	5.5	364	8
# - 96	1.5	43.34	35	4.75	316	7
# - 97	5	43.34	115	20.7	242	5
# - 98	2.5	43.34	58	14.25	175	4
# - 99	2	43.34	46	11	182	4
				Total (57 runs) :		572
				Average (mg/hour/ft^2):		10

TABLE 3

Sheet

Amerace cartridge						
Size of sheet:	48.4	ft^2				
# of run	Amount of phenol (g)	Total water volume (L)	Conc. of phenol (mg/L)	Reaction time (hour)	Reaction rate (mg/hour)	Reactor capacity (mg/hr/ft^2)
# - 5	5	35.7	140	9.2	543	11
# - 6	5	50.3	99	11.5	435	9
# - 8	10	33.98	294	36.8	272	6
# - 12	5	37.8	132	7.8	641	13
# - 25	10	31.2	321	12.8	781	16
# - 26	10	40	250	12.3	813	17
# - 27	7.5	38	197	8.2	915	19
# - 28	15	42.3	355	25.1	598	12
# - 29	15.01	43.3	347	35	429	9
# - 30	2.5	36.4	69	4.5	556	11
# - 31	15	38.1	394	29.75	504	10
# - 33						
# - 37	5			15.75	317	7
# - 38	2.5	42.65	59	6.7	373	8
# - 40	2.5	43.34	58	5.3	472	10
# - 41	1	42.65	23	2.75	364	8
# - 42	1	46.11	22	2.25	444	9
# - 43	1	42.65	23	2	500	10
# - 44	1	42.99	23	1.4	714	15
# - 45	1	42.99	23	1.3	769	16
# - 46	1.5	43.69	34	2	750	15
# - 47	1	42.65	23	1.5	667	14
# - 48	1.5	43.69	34	1	1500	31
# - 49	1.5	42.65	35	2.2	682	14
# - 50	1.5	42.65	35	1.9	789	16
# - 51	1.5	43.34	35	1.7	882	18
# - 52	5	42.65	117	5.75	870	18
# - 53	0.5					
# - 54	0.5					
# - 55	0.5					
# - 56	0.5					
# - 57	0.5					
# - 58	1.5					
# - 60	5	43.34	115	25.3	198	4
# - 61	5	43.34	115	19	263	5
# - 63	5	43.3	115	23.6	212	4
# - 64	5	45	111	8.3	602	12
# - 65	2	43.6	46	3.7	541	11
# - 66	1.5	43.6	34	2.8	536	11
# - 67	2.5	43.6	57	4.8	521	11
# - 68	2	43.6	46	4.2	476	10
# - 71	2.5	43.67	57	4.9	510	11
# - 73	5	43.69	114	12	417	9
# - 75	2	43.69	46	5.3	377	8

From these results, it may be seen that because the packing density of bacteria in the SRE system is 4.4 times higher than that in the FMC/ Amerace cartridge, the operating rate per square foot of power support for the SRE cartridge to 2.1 times that of the Amerace/FMC cartridge.

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I claim

1. Process for the preparation of a potential energy field reactor for processing a reagent in feedstock selected from the group consisting of non-aqueous and aqueous feedstocks with, reactant particles adsorbed therein, which comprises:

a) providing a flow pathway in said reactor having a least one surface,

b) feeding to said pathway, reactant particles and at least one initial reagent reactable therewith during their passage through said pathway in such a manner that an energy potential difference is generated between the beginning of said pathway and its end and said reactant particles become polarized whereby polarized particles adhere to each other and become immobilized within said pathway.

2. The method of claim 1 wherein said reactant particles and said reagent are fed to said reactor until the surface or portions of the surface thereof in said pathway is coated with a plurality of layers of said reactant particles.

3. The method of claim 1 wherein the pathway is a spiral pathway.

4. The method of claim 1 wherein said reactant particles and said reagent are fed to said reactor until reactant particles adhere to the surface thereof.

5. The method of claim 3 wherein the reactant is a biocatalyst.

6. The method of claim 5 wherein the biocatalyst is aerobic or anaerobic.

7. The method of claim 6 wherein said biocatalyst is selected from the group consisting of enzymes, bacteria, organelles, yeasts, leucocytes, hemocytes and fungi.

8. The method of claim 1 wherein the feedstock is aqueous.

9. The method of claim 1 wherein the feedstock is non-aqueous.

10. The method of claim 1 wherein the initial reagent is the reagent in the feedstock to be processed.

11. The method of claim 8 wherein the reactant is aerobic bacteria and the initial reagent is an oxidizing agent.

12. The method of claim 11 wherein the reactant is aerobic bacteria and the initial reagent is oxygen.

13. The method of claim 11 wherein the reactant is activated sludge.

14. The method of claim 13 wherein the reactant is activated sludge screened to have a particle size of less than 300 microns.

15. A potential energy field reactor for reacting feedstock with reactant particles immobilized in the feedstock pathway thereof produced in accordance with the method of claim 1.

16. The reactor of claim 15 wherein the pathway is a spiral pathway.

17. A method of processing one or more components of a feedstock which comprises feeding said feedstock to a reactor of claim 15.

18. The method of removing phenolic components from aqueous feedstock which comprises feeding said feedstock to a reactor of claim 17.

19. The method of claim 18 which comprises recycling said feedstock through said reactor till no measurable amount of phenolic components is detectable.

20. The method of utilizing an external magnet or an internally generated magnetic field to control the reaction of Claim 1.

21. The method of utilizing an external magnet or an internally generated magnetic field to control the reaction of Claim 17.

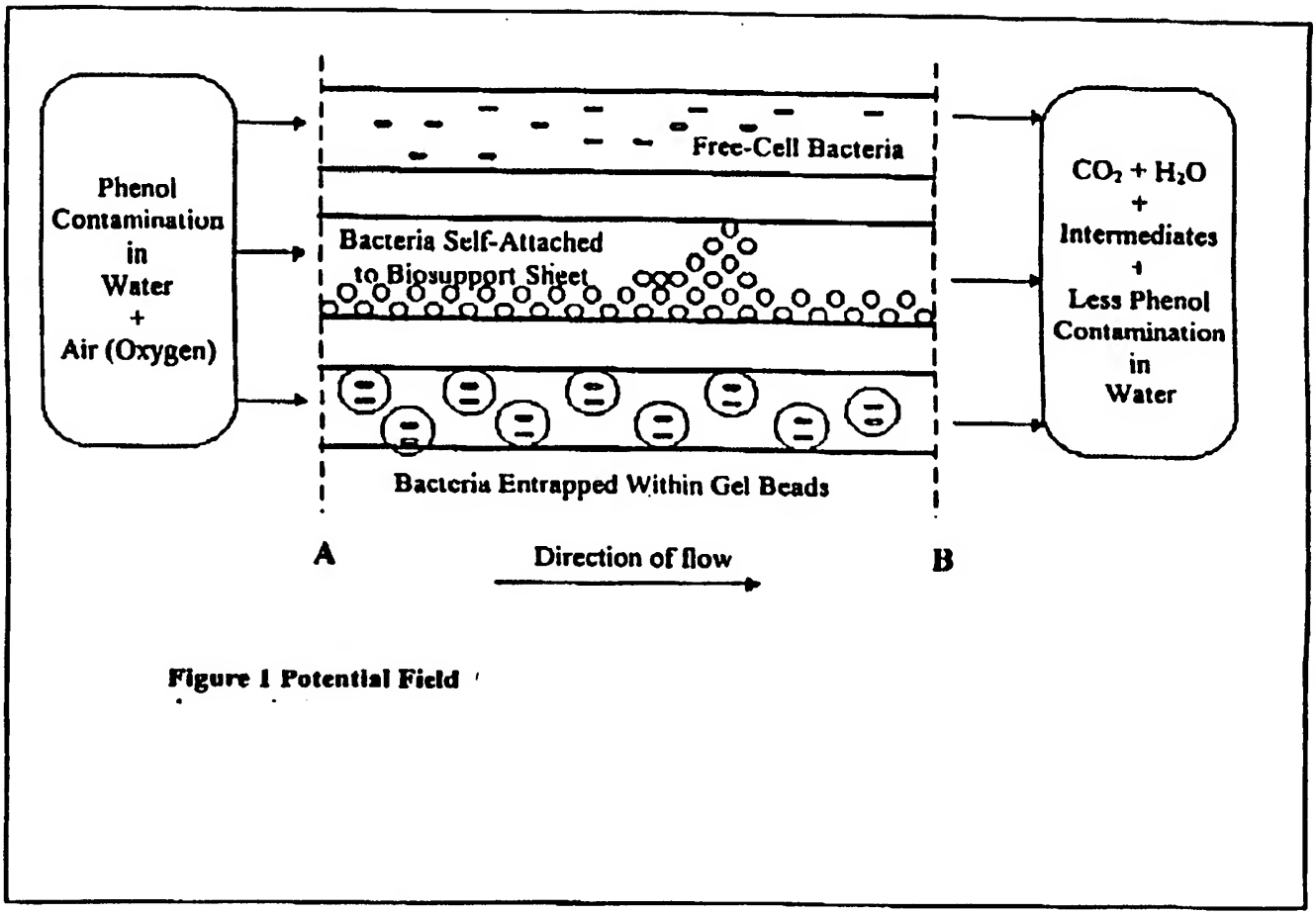

Figure 1 Potential Field

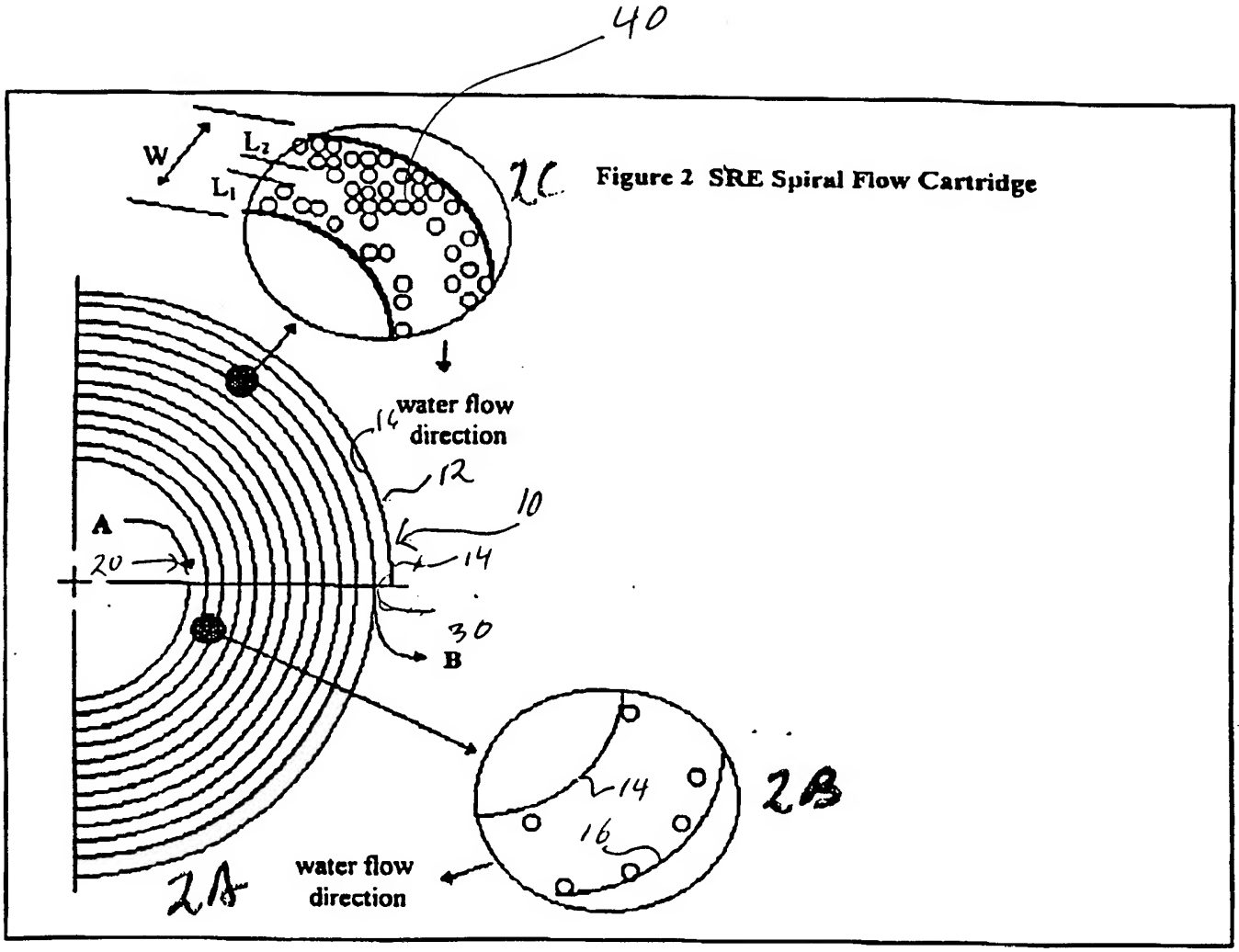

Figure 2 SRE Spiral Flow Cartridge

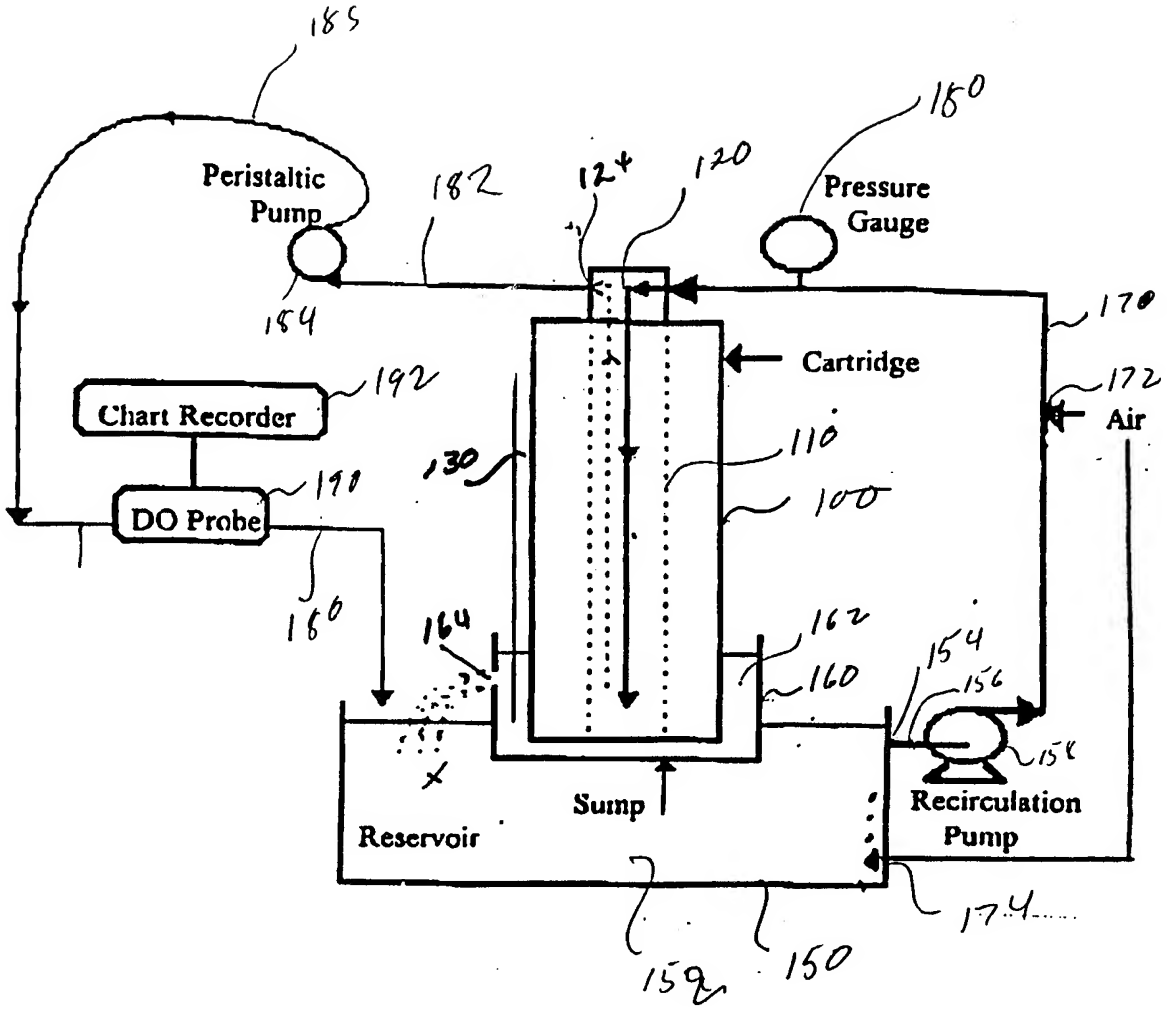
185
Peristaltic Pump
182
124
120
180
Pressure Gauge
154
170
Cartridge
192
Chart Recorder
172
Air
130
110
190
DO Probe
100
160
164
162
154
156
158
Sump
Reservoir
Recirculation Pump
174
152
150

FIGURE 3